AD-A039 043 HONEYWELL INC GOLDEN VALLEY MINN CERAMICS CENTER F/G 9/1
MANUFACTURING METHODS AND TECHNIQUES FOR PIEZOELECTRIC ENGINEER--ETC(U)
OCT 76 W B HARRISON, L HILTNER, W KAMMEYER DAAB07-76-C-0008
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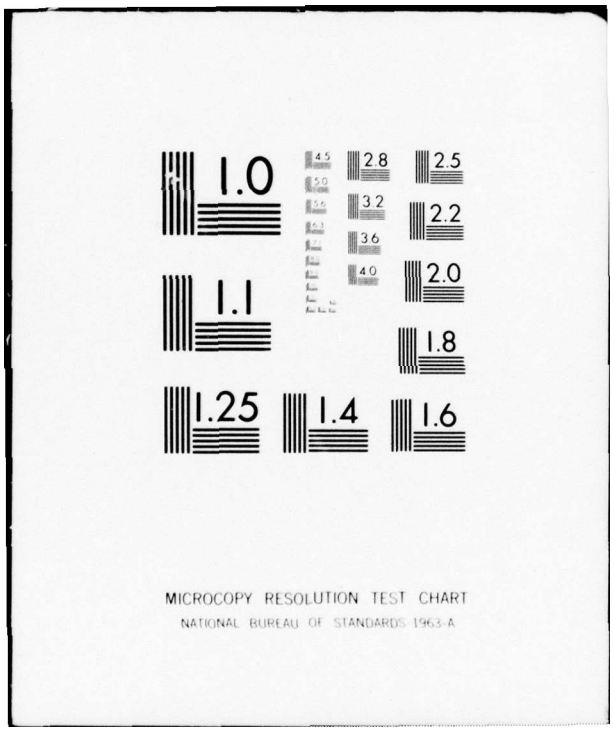
1.0
1.1
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1.8
2.0
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2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

12

FIFTH QUARTERLY PROGRESS REPORT

PRODUCTION ENGINEERING MEASURE (PEM)

MANUFACTURING METHODS AND TECHNIQUES FOR PIEZOELECTRIC TRANSFORMERS

CONTRACT DAAB07-76-C-0008

July 14, 1976 to October 14, 1976

PLACED BY:

PRODUCTION DIVISION, PROCUREMENT AND
PRODUCTION DIRECTORATE, USAECOM
FORT MONMOUTH, NEW JERSEY

CONTRACTOR

HONEYWELL INC.
GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION
CERAMICS CENTER
GOLDEN VALLEY, MINNESOTA

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Transformers
Lead zirconate-lead titanate ceramics
Night vision goggles
Image intensifier tubes

20. ABSTRACT (CONTINUE ON REVERSE SIDE IF NECESSARY AND IDENTIFY BY BLOCK NUMBER)

The Fifth Quarterly Report for Contract DAAB07-76-C-0008 describes the progress and status of this program to establish a cost-effective production capability for 18mm and 25mm piezoelectric ceramic transformers. Based on the low efficiency of the 18mm PETS a review of the 18mm design was conducted and three additional first engineering samples were built and evaluated. Test results on these samples and a revised specifications are presented in this report.

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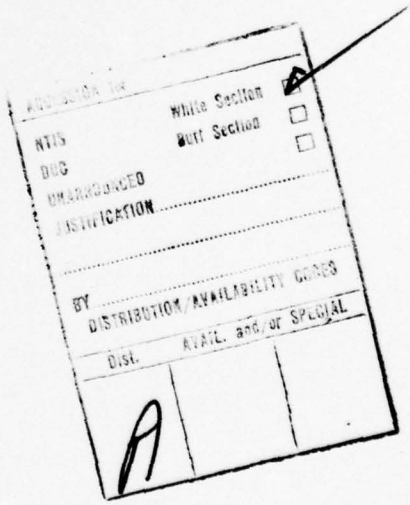
SECURITY CLASSIFICATION OF THIS PAGE (WHEN DATA ENTERED)

FIFTH QUARTERLY REPORT

CONTRACT NO.	DAAB07-76-C-0008 Manufacturing Methods and Techniques for Piezoelectric Transformers
PERIOD COVERED:	July 14, 1976 - October 14, 1976
PREPARED BY:	W. Harrison L. Hiltner W. Kammeyer

OBJECT OF STUDY:

The objective of this contract is to establish a production capability for 18mm and 25mm piezoelectric ceramic transformers with all required manufacturing methods, test procedures and production tooling for high production rates. These transformers are to be used in conjunction with a power supply for operating night vision image intensifier tubes.



DISTRIBUTION STATEMENT

UNCLASSIFIED: "Approval for public release, distribution unlimited"

ABSTRACT

The Fifth Quarterly Report for Contract DAAB07-76-C-008 describes the progress and status of this program to establish a cost-effective production capability for 18mm and 25mm piezoelectric ceramic transformers. Because of the low efficiency of the 18mm PETS, a review of the 18mm design was conducted and three additional first engineering samples were built and evaluated. Test results on these samples and revised specifications are presented in this report.

PURPOSE

This Production Engineering Measure (PEM) contract covers all of the tooling, test methods, package designs, mounting techniques, interconnection techniques and other manufacturing methods and techniques required for eventual production of 18mm and 25mm piezoelectric transformers. These units are to be used with a power supply to improve the performance and reduce cost for image intensifier tubes used in various night vision devices.

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LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I
APPROACH

Our approach to both the 18mm and 25mm PET designs, its advantages and the analytical method used to determine performance of these transformers was discussed in the first quarterly report[1].

(1) First Quarterly Progress Report, Production Engineering Measures (PEM), Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, July 14, 1975 to October 14, 1975.

SECTION II
PROCESS REVIEW

This section updates the status of each process step planned for manufacturing the 18mm PETs because of a change in the number of elements used and the electrical load on the PET output. No changes on the 25mm process have been made.

This section discusses only those manufacturing procedures completed thus far in the first five quarters of this program. Each operation given has been previously[2][3][4] identified with a number, description and a list of the materials, tools, fixtures and procedures required to complete this operation. Only operations revised or not previously described are discussed. Appendix A contains a list of those drawings for the 18mm and 25mm PETs revised during this quarter.

(2) Second Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, October 14, 1975 to January 14, 1976.

(3) Third Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C0008, January 14, 1976 to April 14, 1976.

(4) Fourth Quarterly Progress Report, Production Engineering Measure (PEM) Manufacturing Methods and Techniques for Piezoelectric Transformers, Contract Number DAAB07-76-C-0008, April 14, 1976 to July 14, 1976.

Manufacturing Procedure for
18mm and 25mm Packaged PETs

OP 010 Slug Processing (no change)

OP 020 Hot Press Slugs (no change)

OP 030 Blanchard Grind Slugs (top and bottom) (no change)

OP 040 Core Drill Slugs (no change)

OP 050 Hone I. D. of slugs (no change

OP 060 Grind O. D. of slugs (no change)

OP 065 Slice 25mm Half Torroids (no change)

OP 070 Mount and Slice Slugs (no change)

OP 080 Clean Elements (no change)

OP 090 Inspection of Unelectroded 18 and 25mm Elements (no change)

OP 100 Apply Silver Electrodes (no change)

OP 110 Silver Fire (no change)

OP 120 Polarization (no change)

OP 130 Check Polarity (no change)

OP 140 PET Package Preparation 18mm (no change)

OP 140 PET Package Preparation 25mm (no change)

OP 150 Top Case Element Assembly

C. 3 (to read) Fold each wire into proper place (P_-, V_{12} and V_3) per 28100560 or 28100561 and attach with conductive epoxy or solder. (This completes the 18mm assembly)

C. 4 (to read) Add nonconductive epoxy and next elements. (28100561 only)

C. 6 (to read) Fold in place P_+ wires and attach with conductive epoxy per Dwg. 28100561. Add nonconductive epoxy and next element.

OP 160 Process Control Electrical Check (no change)

Op 170 Final Package Assembly (no change)

OP 180 Final Inspection (no change)

SECTION III
STATUS AND FUTURE WORK

This section describes the status of work against the various tasks outlined in Figure 1 which were active during this fifth quarter of the program.

A. TASK 1-6

Work completed previously.

B. TASK 7 - POLARIZATION TOOLING

Work on the polarization tooling has been delayed until next quarter.

C. TASK 8-13

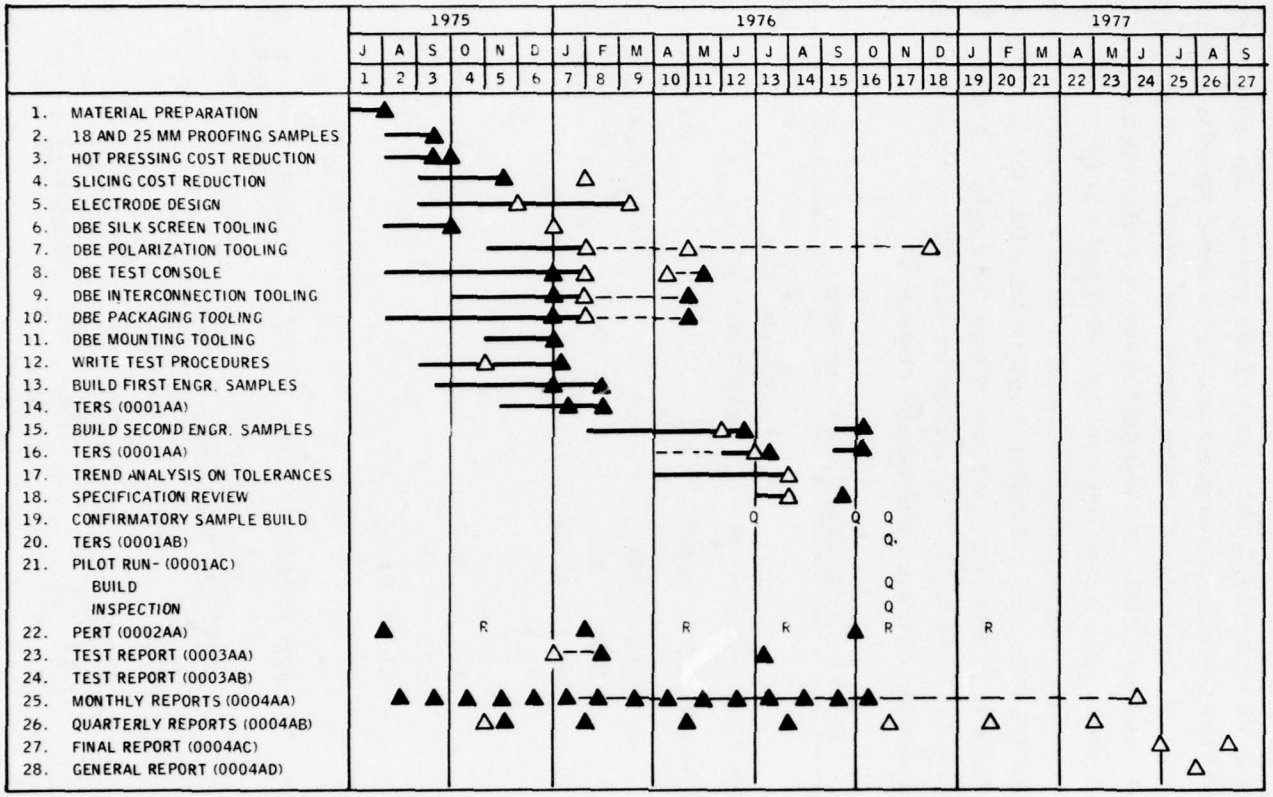
Work completed previously.

D. TASK 14 - TEST AND EVALUATION OF FIRST ENGINEERING SAMPLES

Life test on the three 18mm and three 25mm PETs has reached 2000 hours without a failure. This completes their like testing cycle. These parts were delivered to N. V. L. on July 20, 1976.

E. TASK 15 - SECOND ENGINEERING SAMPLE BUILD

Based on the low efficiency and marginal voltage step-up ratio achieved in the 12 18mm PETs built earlier, several modifications to the 18mm PET design have been made, as noted in Section II. Three additional packaged units were built with the following changes: One element was eliminated because of the higher step-up voltages achieved. The electrical load on each secondary was altered to make it more compatible with an 18mm power supply. These conditions are a V_{12} loading of 2×10^6 ohms and 8 pf and a V_3 loading of 1×10^8 ohms and 3 pf.



DBE DESIGN BUILD AND EVALUATE
TERS TEST AND EVALUATION REVIEW AND SUBMIT
R REVISE QUARTERLY AS REQUIRED
Q REQUEST FOR APPROVAL TO START
△ ORIGINAL OR REVISED COMPLETION DATES
▲ ACTUAL COMPLETION DATES

Figure 1. Program Status against Schedule

F. TASK 16 - TEST AND EVALUATION OF SECOND ENGINEERING SAMPLE

Life test sampling for the three 18mm PETs was continued until July 20, 1976. They were delivered to N. V. L. after about 1000 hours of evaluation, whereas the three other 25mm PETs were continued for their full 2000 hours of life testing. No failures occurred during these tests. Additional test data was generated on the three samples built to evaluate the single element design and new loading conditions. Table I compares the data obtained for these three units (025, 026 and 027) against a double element unit (020) at several loading conditions. The thinner element unit (026) had 7 to 10 percent lower efficiency and also lower voltage step-up than the normal thickness unit (027). The well-aged unit (025) had the same efficiency but higher step-up voltage than the newer unit (027). The double unit (020) had a 10 percent lower efficiency than the single unit (025). The impact of different electrical loads on the PET is seen for unit 027. The power supply loading produced the maximum efficiency and voltage step-up.

Table I. Additional 18mm Test Data

	LOAD	$10^7\Omega$ and 10pf		$10^7\Omega$ and 8pf		V_{12} $2\times10^6\Omega$ and 8pf V_3 $1\times10^8\Omega$ and 3pf		Remarks
		RT	-54°C	RT	-54°C	RT	-54°C	
S/N 025	Step-up V_{12}	196		213	102			Single Ceramic Element, 0.010-in. thick, well-aged part.
	Step-up V_3	176		192	89			
	F_R kHz	32.66		32.81	31.73			
	Percent Eff.	26.5		35.1				
S/N 026	Step-up V_{12}	121		135	88			Single Ceramic Element, 0.008-in. thick, 14-day-old part.
	Step-up V_3	128		140	89			
	F_R kHz	31.73		31.93	31.21			
	Percent Eff.	19.6		25.7				
S/N 027	Step-up V_{12}	160		176	101	181	120	Single Ceramic Element, 0.010-in. thick, 30-day-old part.
	Step-up V_3	164		178	104	110	75	
	F_R kHz	32.23		32.43	31.82	32.28	31.79	
	Percent Eff.	28.1		35.1		41.7	18.4	
S/N 020	Step-up V_{12}			228		216	96	Double Ceramic Element, 0.010-in. thick, well-aged part.
	Step-up V_3			222		160	76	
	F_R kHz			32.85		32.74		
	Percent Eff.			24.7		40.8		

G. TREND ANALYSIS ON TOLERANCES

A tolerance analysis has been completed and implemented in the drawings contained in the fourth quarterly report[4] and those revised in Appendix A.

H. SPECIFICATION REVIEW

A review of the initial second engineering test data was conducted on 7/20/76 and 9/17/76. In the second review it was concluded that the 25mm design was acceptable; however, the 18mm design needed further study as well as three additional proof samples. These were built and evaluated, as discussed above. The revised specification (Appendix B) and a second request to start the confirmatory built were submitted October 7, 1976.

I. CONFIRMATORY BUILD

Approval to start confirmatory build expected about 12/1/76.

SECTION IV
CONCLUSIONS

The revised specification and additional 18mm second engineering samples appear to meet all requirements for the 18 and 25mm PET; therefore, we appear to be ready for the next confirmatory build phase.

SECTION V
RECOMMENDATIONS

It is recommended that the revised specifications be approved and the confirmatory build be initiated.

SECTION VI
REPORTS

The fourth quarterly report on this program was approved and has been published and distributed during this report period. No other reports or publications have been made on this program.

SECTION VII
IDENTIFICATION OF PERSONNEL

During the fifth quarter of this program, the following personnel worked the indicated hours in their area of responsibility. No new professional persons, whose backgrounds have not been given previously[1][2], were used.

Individual	Responsibility	Hours
W. B. Harrison*	Program Manager	26
W. H. Kammeyer*	Production Engineer, Ceramic Manufacture and PET Assembly	21
L. F. Hiltner*	Quality Engineer	40
M. P. Murphy	Ceramic Technician Ceramic Manufacturing	17
R. Ripley	Insp. PET Testing	14
R. Erickson	Drafting	3

*Backgrounds given in First and Second Quarterly Reports

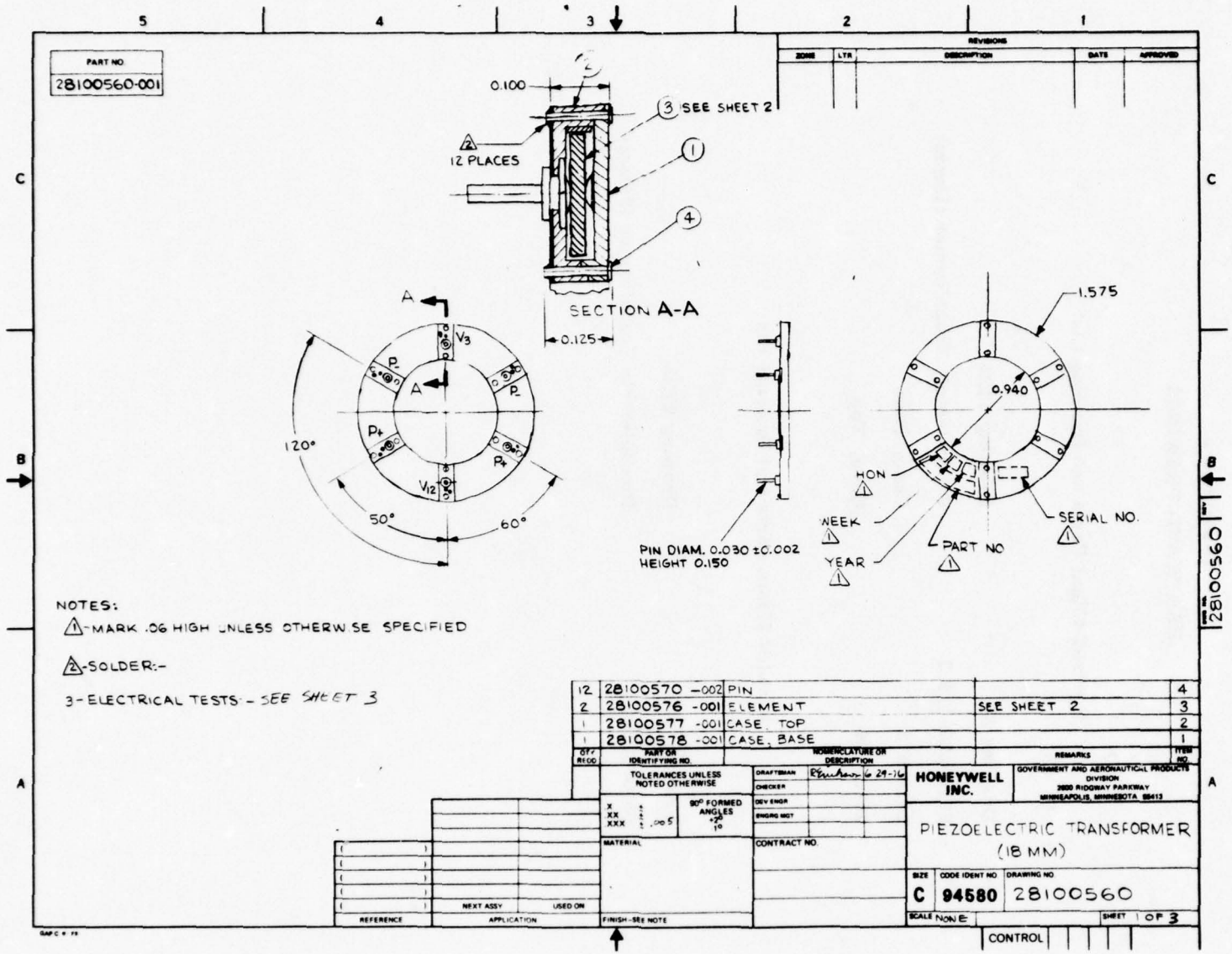
APPENDIX A
PARTS AND DRAWINGS

Revised 18mm Parts and Drawing List

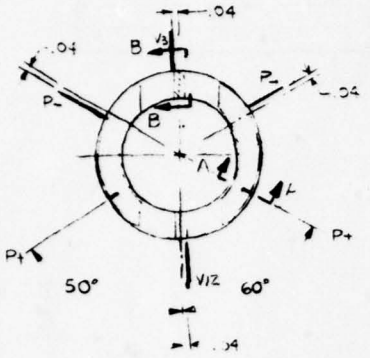
Drawing No.	Drawing Title
28100560-1, 2, 3	Piezoelectric Transformer (18mm)
28100578	Case, Base
28100574	Case, Top

Revised 25mm Parts and Drawing List

Drawing No.	Drawing Title
28100561-3	Piezoelectric Transformer (25mm)


PART NO.
28100560-001
REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
0.100
12 PLACES
SEE SHEET 2
SECTION A-A
0.125
120°
50°
60°
PIN DIAM. 0.030 ±0.002
HEIGHT 0.150
1.575
0.940
MON
WEEK
YEAR
PART NO
SERIAL NO.
NOTES:
1-MARK .06 HIGH UNLESS OTHERWISE SPECIFIED
2-SOLDER:-
3-ELECTRICAL TESTS:- SEE SHEET 3
12 | 28100570 -002 | PIN | | 4
2 | 28100576 -001 | ELEMENT | SEE SHEET 2 | 3
1 | 28100577 -001 | CASE, TOP | | 2
1 | 28100578 -001 | CASE, BASE | | 1
QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | REMARKS | ITEM NO.
TOLERANCES UNLESS NOTED OTHERWISE
X ±
XX ±
XXX ± .005
90° FORMED ANGLES ±2°
MATERIAL
FINISH-SEE NOTE
DRAFTSMAN
CHECKER
DEV ENGR
ENGRG MGT
CONTRACT NO.
HONEYWELL INC.
GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION
2600 RIDGWAY PARKWAY
MINNEAPOLIS, MINNESOTA 55413
PIEZOELECTRIC TRANSFORMER
(18 MM)
SIZE C
CODE IDENT NO. 94580
DRAWING NO. 28100560
SCALE NONE
SHEET 1 OF 3
CONTROL
REFERENCE | APPLICATION | NEXT ASSY | USED ON
28100560

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



SECTION A-A
TYPICAL OF P+

SECTION B-B
TYPICAL OF 4

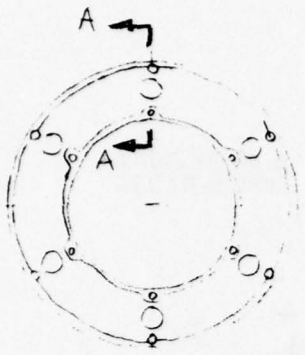
LAMINATION DETAIL

SIZE	CODE IDENT NO.	DRAWING NO.
C	94580	28100560
SCALE	WT	SHEET 2 OF 2

28100560 REV

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

PART NO.
28 005[illegible]-001



NOTES:
1. -SILASTIC PRIMER
2. -SILASTIC PAD

CASE, BASE - 28100581
SECTION A-A

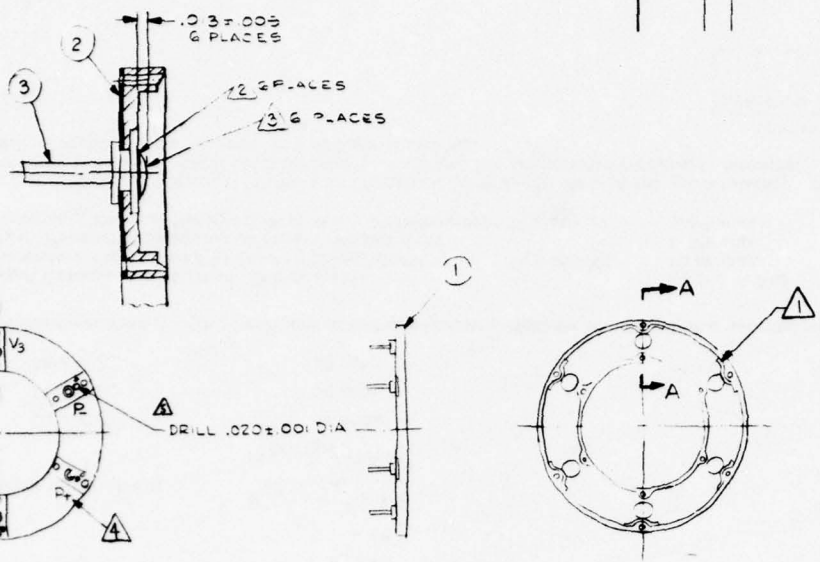
1	28100[illegible]-1	[illegible]				18 mm	1

		TOLERANCES UNLESS NOTED OTHERWISE	DRAFTSMAN [illegible] 6/30/76	HONEYWELL INC.	GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION 2600 RIDGWAY PARKWAY MINNEAPOLIS, MINNESOTA 55413
		X ± XX ± XXX ± ANGLE ±	CHECKER		
			DEV ENGR		
		MATERIAL	ENGRG MGT	CASE, BASE	
			CONTRACT NO		
28100560	P2T [illegible]			SIZE B	CODE IDENT NO 94580
NEXT ASSY	USED ON			SCALE	SHEET
APPLICATION		FINISH-SEE NOTE		CONTROL	

DAP 8 • 73

PART NO.
28100574-001

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



NOTES:

1. TRANSFER TAPE
2. SILASTIC PRIMER
3. SILASTIC PAD
4. MARKING APPROX .2 H GH
5. USE SHORTING BAR 28100579-001 TO LOCATE DRILLED HOLES

ITEM NO.	QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	REMARKS
3	6	28100572-001	TERMINAL	
2	1	28100579-001	SHORTING BAR	
1	1	28100580-001	CASE, TOP MOLDING	

TOLERANCES UNLESS NOTED OTHERWISE		90° FORMED ANGLES
X	±	+2°
XX	±	-1°
XXX	±	

DRAFTSMAN: R. Knudsen 6 30 76
CHECKER
DEV ENGR
ENGRG MGT
MATERIAL
CONTRACT NO.
FINISH-SEE NOTE

REFERENCE	NEXT ASSY	USED ON

APPLICATION

HONEYWELL INC.
GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION
2600 RIDGWAY PARKWAY
MINNEAPOLIS, MINNESOTA 55413

CASE, TOP
18 mm

SIZE	CODE IDENT NO.	DRAWING NO.
C	94580	28100574

SCALE
SHEET

CONTROL

28100574

ELECTRICAL REQUIREMENTS

When a 5 volt (p-p) sine wave input voltage to the PET is applied in parallel to the primary terminals (P_+ and P_-) and the ceramic is driven at its primary resonant frequency with an electrical load on each secondary terminal (V_{12} and V_3) of 10 megohms and 10 pf, the packaged units shall meet the following electrical requirements.

Resonant Frequency:	
22 ± 2°C	30.5 ± 1.5 kHz
52 ± 2°C	30.7 ± 1.5 kHz
-54 ± 2°C	29.5 ± 1.5 kHz

Stepup Voltage Ratio	V_{12} or V_3 output/input voltage
22 ± 2°C	195 ± 30
52 ± 2°C	195 ± 30
-54 ± 2°C	90 + 15 - 10

Percent Efficiency $= \dfrac{V_{12}^2 + V_3^2 \times 100}{(V_{in})(I_{in})(10 \times 10^6)}$

22 ± 2°C	50 min.
52 ± 2°C	50 min.
-54 ± 2°C	20 min.

Capacitance and Dissipation Factor: The input and output capacitance shall be measured at a nominal voltage and drive of 1 volt and 1 kHz.

Input Capacitance at Room Temperature		32.0 ± 3.2 nf
Secondary Capacitance at Room Temperature	V_{12} and V_3	15 pf max.
Input Percent Dissipation at Room Temperature		1.5% max.
Secondary Percent Dissipation at Room Temperature	V_{12} and V_3	1.5% max.

The package PET unit must meet the requirements as described in SCS-480 Rev. A for solderability, resistance to solder heat, terminal strength, induced voltage, thermal shock, high and low temperature storage, humidity, mechanical shock and vibration, reduced barometric pressure, life and workmanship.

Electrical Requirements

Size	Code Ident No.	Drawing No.
C	94580	28100561

Revision II
September 22, 1976

APPENDIX B

HONEYWELL RECOMMENDED SPECIFICATION FOR PIEZOELECTRIC CERAMIC HIGH VOLTAGE TRANSFORMERS

1.0 SCOPE

1.1 Scope. This specification covers the requirements for voltage step-up transformers using piezoelectric ceramic materials which are manufactured by hot pressing techniques.

2.0 APPLICABLE DOCUMENTS

2.1 Government documents. The following documents of the issue in effect on the date of invitation for bid on request for proposal, form a part of this specification to the extent specified herein:

Specifications

Military

MIL-T-27	-	Transformers and Inductors, General Specification For.
MIL-Q-9858	-	Quality Program Requirements.

Standards

MIL-STD-105	-	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-130	-	Identification Marking of U.S. Military Property.
MIL-STD-202	-	Test Methods for Electronic and Electrical Component.
MIL-STD-456	-	Electronic Parts, Date and Source Coding For.

3.0 REQUIREMENTS

3.1 Item definition. The piezoelectric ceramic transformer (PET), shall be a solid state electronic device which when driven at its resonant frequency by a regulated oscillator shall provide two separate appropriate AC voltage step-up ratios for powering parallel type voltage multipliers for operating image intensifier tubes. The PET shall consist of one to four elements mounted in a plastic case (see Figure 1 and Figure 2).

3.2 Materials. The PET shall consist of one to four individual ceramic elements. A $PbTiO_3$-$PbZrO_3$ material must be selected for use in these elements to meet the electrical and mechanical requirements specified herein. Other materials selected for mounting and packaging the elements into the PET shall be as specified herein and in accordance with MIL-T-27.

3.3 Physical characteristics. The physical characteristics of the PET shall be as specified herein and in accordance with Figure 1 or Figure 2. The weight requirement shall be 5 grams maximum (see 4.5.2).

3.4 Resistance to soldering heat. The PET shall show no evidence of mechanical or electrical damage after immersion in a molten solder pot at 280°C for 30 seconds (see 4.5.6). The PET shall meet the resonant frequency (3.8.1), efficiency at resonance (3.8.2) and voltage step-up at resonance (3.8.3) after subjection to resistance to soldering heat.

3.5 Solderability. The PET shall be solderable (see 4.5.9).

3.6 Terminal strength. The PET shall show no evidence of loosening of the terminals, or other mechanical damage, when a pull of 1/2 pound is applied (see 4.5.7).

3.7 Induced voltage. The PET shall show no evidence of continuous arcing or breakdown nor shall there be an abrupt change in input current when a voltage is applied to the primary sufficient to cause 150 percent of the rated input voltage; i.e., 7.5 volts (p-p) (see 4.5.8).

3.8 Electrical performance. The 18mm and 25mm PET shall meet the requirements given in Figure 1 and Figure 2 respectively.

3.9 Thermal shock. The PET shall show no evidence of mechanical or electrical damage after subjection to thermal shock (see 4.5.14).

3.10 High temperature storage. The PET shall show no evidence of mechanical or electrical damage after subjection to a temperature of 71°C for a minimum of 8 hours (see 4.5.15).

3.11 Low temperature storage. The PET shall show no evidence of mechanical or electrical damage after subjection to storage at a temperature of -65°C for a minimum of 2 hours (see 4.5.16).

3.12 Humidity. The PET shall show no evidence of mechanical or electrical damage after exposure to a relative humidity of not less than 95 percent at a temperature of plus 52°C for a minimum of 6 hours (see 4.5.17).

3.13 Mechanical shock. There shall be no evidence of mechanical damage after subjection to mechanical shock (see 4.5.13).

3.14 Mechanical vibration. With the operating input potential applied to the PET, there shall be no evidence of continuous arcing or breakdown, nor shall there be any abrupt changes in input current during and after subjection to mechanical vibration. There shall be no evidence of mechanical damage during and after subjection to mechanical vibration (see 4.5.12).

3.15 Reduced barometric pressure. The PET shall show no evidence of mechanical damage, continuous arcing or breakdown nor shall there be any abrupt changes in input current after subjection to a barometric pressure of 3.44 inches for one hour (see 4.5.10).

3.16 Life. The PET voltage step-up at resonant frequency shall not decrease greater than 1 percent nor increase greater than 5 percent from the initial measurement during and after subjection to an elevated temperature of 52°C for 2000 hours of operation. The PET shall meet the induced voltage (4.5.8), resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2), input capacitance and dissipation factor (4.5.3.4), and secondary capacitance and dissipation factor (4.5.3.5) after subjection to an elevated temperature of 52°C for 2000 hours of operation (see 4.5.11).

3.17 Identification and marking. The PET shall be marked in accordance with MIL-STD-130 with the manufacturer's name or code symbol, terminal identification, and date code in accordance with MIL-STD-436. Terminal and part number identification shall be in accordance with Figure 1.

3.18 Workmanship. The PETs shall be processed in such a manner as to be uniform in quality and appearance (see 4.5.2).

4.0 QUALITY ASSURANCE PROVISIONS (TEST PROCEDURES)

4.1 Responsibility for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, which is acceptable to the government. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of inspection. The examination and testing of PETs shall be classified as follows:

a. Confirmatory build inspection (does not include preparation for delivery (see 4.3).

b. Quality conformance inspection (does not include preparation for delivery) (see 4.4).

4.3 Confirmatory build inspection.

4.3.1 The PETs of each type as noted in 3.3 shall be tested as specified in Table I in the order shown.

4.3.2 No failures shall be permitted.

4.4 Quality conformance inspection.

4.4.1 Group A inspection. Group A inspection shall consist of the examination and tests specified in Table II, in the sequence as shown.

4.4.1.2 Sampling plan. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection II. The AQL shall be as specified in Table II of this specification. Major and minor defects shall be as defined in MIL-STD-105.

4.4.2 Group B inspection. Group B inspection shall consist of the tests specified in Table III of this specification in the sequence as shown. Group B inspection shall be performed on sample units that have been subjected to and have passed group A tests unless it is more practical to select a separate sample from the Lot for group B inspection.

4.4.2.1 Sampling plan. The sampling quantities for each type transformer shall be as specified in Table III. No more than one failure shall be allowed for each respective subgroup.

4.4.2.2 Rejected lots. If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit the lot for inspection. Resubmitted lots shall be inspected using group B inspection quantities and tests as shown in Table III.

4.5 Method of examination and test.

4.5.1 Inspection conditions. Test will be conducted in accordance with the test procedure specified herein. Unless otherwise specified, the following conditions shall apply.

a. Inspections and test shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

b. Capacitance load to the PET shall be 10 pf ± 5 percent for each element or as indicated in Figure 1.

c. Resistive load to the PET shall be 10 megohm ± 1 percent for each element or as indicated in Figure 1.

d. Test frequency shall be within ± 2 percent of the nominal value.

e. Applied voltage to the primary shall be 5 volts ± 1 percent peak to peak sine wave input.

4.5.2 Visual and mechanical examination.

4.5.2.1 External. PETs shall be examined to verify that the physical dimensions and weight (see 3.3), marking (see 3.17) and workmanship (see 3.18) are in accordance with the applicable requirement. PETs shall be weighed with a balance scale having an accuracy of 0.2 gram.

4.5.2.2 Internal. PETs shall be disassembled and examined to verify that the materials, internal lead wires, internal mounting, and workmanship are in accordance with the applicable requirements (see 3.3 and 3.18).

4.5.3 Room temperature electrical performance. (see 3.8)

4.5.3.1 Resonant frequency. With rated voltage applied to the primary of the PET, the secondary voltage shall be measured while the supply frequency is varied over the specified frequency range with the primary voltage held constant. All resonant frequencies shall be noted. Measurements shall be performed at the load condition specified in Figures 1 and 2.

4.5.3.2 Efficiency at resonance. The PET shall be operated at resonance in accordance with 4.5.3.1. At the loads specified in 4.5.3.1 the primary a.c. current and secondary rms voltage shall be measured. Efficiency at resonance shall be calculated as:

$$\frac{(V_{12}^2 + V_3^2)100}{V_{in} I_{in} R_L}$$

4.5.3.3 Voltage step-up at resonance. The PET shall be operated at resonance in accordance with 4.5.3.1. At the loads specified in 4.5.3.1, the voltage output at the secondary shall be measured. Voltage step-up at resonance of each output shall be calculated as:

$$\frac{V_{12}(\text{Secondary})}{V_{in}(\text{Primary})} \text{ and } \frac{V_{3}(\text{Secondary})}{V_{in}(\text{Primary})}$$

4.5.3.4 Input capacitance and dissipation factor. The input capacitance and dissipation factor for the PET shall be determined by a capacitance bridge or other suitable means at 1 volt rms at 1 kHz applied between the two parallel primaries and the two parallel grounds.

4.5.3.5 Secondary capacitance and dissipation factor. The capacitance and dissipation factor of each secondary shall be determined by a capacitance bridge or other suitable means at 1 volt rms at 1 kHz applied between the secondary and ground.

4.5.4 High temperature electrical performance. The PET shall be maintained for a minimum of 1 hour at a temperature of plus 52°C. (see 3.8)

4.5.4.1 Resonant frequency. The resonant frequency shall be determined for operation at plus 52°C in accordance with 4.5.3.1.

4.5.4.2 Efficiency at resonance. The efficiency at resonance shall be determined for operation at plus 52°C in accordance with 4.5.3.2.

4.5.4.3 Voltage step-up at resonance. The voltage step-up at resonance shall be determined for operation at plus 52°C in accordance with 4.5.3.3.

4.5.4 Low temperature electrical performance. The PET shall be maintained for a minimum of 1 hour at a temperature of minus 54°C. (see 3.8)

4.5.5.1 Resonant frequency. The resonant frequency shall be determined for operation of minus 54°C in accordance with 4.5.3.1.

4.5.5.2 Efficiency at resonance. The efficiency at resonance shall be determined for operation at minus 54°C in accordance with 4.5.3.2.

4.5.5.3 Voltage step-up at resonance. The voltage step-up at resonance shall be determined for operation at minus 54°C in accordance with 4.5.3.3.

4.5.6 Resistance to soldering heat. PETs shall be tested in accordance with method 210A of MIL-STD-202. The following details shall apply (see 3.4):

a. Depth of immersion in the molten solder - to a point 3/64 inch from the nearest insulating material.

b. Test-condition letter - B.

c. Measurements after test - resonant frequency, efficiency at resonance and voltage step-up at resonance shall be tested in accordance with 4.5.3.1, 4.5.3.2, and 4.5.3.3.

4.5.7 Terminal strength. PET shall be tested for terminal secureness in accordance with method 211A of MIL-STD-202. The following details and exceptions shall apply:

a. Test-condition letter - A.

b. Applied force - terminal secureness shall be tested by gradually applying a force of 1/2 pound to each pin terminal in the direction of the axis of the terminal (see 3.6).

4.5.8 Induced voltage. A test voltage sufficient to cause 150 percent of the rated input voltage shall be applied to the primary of the PETs. The test potential shall be applied for 5 ± 1/2 second. The load on the secondary shall be as specified in Figures 1 and 2. During the test, PETs shall be examined for evidence of continuous arcing, breakdown, and abrupt changes in input current (see 3.7).

4.5.9 Solderability. PETs shall be tested in accordance with method 208C of MIL-STD-202. Each of the terminals is to be tested. Terminals shall be immersed to within 3/64 inch from the nearest insulating material (see 3.5).

4.5.10 Barometric pressure (reduced). PETs shall be tested in accordance with method 105C of MIL-STD-202. The following details and exceptions shall apply:

a. Method of mounting - none.

b. Test condition letter - B.

c. Tests during subjection to reduced pressure - none.

d. Tests after subjection to reduced pressure - PETs shall be tested as specified in 4.5.8 except that the input voltage to the primary shall be sufficient to cause 125 percent of rated input. PETs shall also be examined for evidence of visual and mechanical damage.

e. Exposure time prior to measurements - one (1) hour (see 3.15).

4.5.11 Life. PETs shall be tested in accordance with Method 108A of MIL-STD-202. The following details shall apply:

a. Distance of temperature measurements from specimens - two (2) inches.

b. Still air requirement, not applicable.

c. Method of mounting and distance between specimens - rigidly mounted; distance between specimens two (2) inches.

d. Test temperature and tolerance, 52°C ± 2°C.

e. Operating conditions - loading equal to 10 pf, 10 megohm and excitation of the primary equal to or greater than 1.25 times rated voltage. The electrical test circuit shall monitor the PETs during test for evidence of arcing, breakdown or abrupt changes in input current.

f. Test condition letter - F.

g. Measurements - Periodic measurements for voltage step-up at resonant frequency shall be made at intervals of 96, 240, 480, and 960 hours. The final measurements shall be made at the end of the 2000 hour life period. After completion of life test, PETs shall be tested for induced voltage (4.5.8), resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2), input capacitance and dissipation factor (4.5.3.4), and secondary capacitance and dissipation factor (4.5.3.5). Samples shall also be examined for evidence of visual and mechanical damage (see 3.16).

4.5.12 Mechanical vibration. The PET shall be rigidly mounted during vibration testing. The rated input voltage shall be applied during vibration testing, load shall be applied to both secondary outputs. The electrical test circuit shall monitor PETs during test for evidence of arcing, breakdown or abrupt changes in input current. After the vibration tests outlined below, the PET shall be tested for resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2) and voltage step-up at resonance (4.5.3.3).

4.5.12.1 Longitudinal vibration. Rigidly mount the PET to the vibration table so that the radial axis of the PET is parallel to the direction of motion. Subject the PET to two (2) each thirty (30) minutes sweeps over the frequency ranges of ten (10) hertz to 3500 hertz and back to ten (10) hertz while maintaining a constant 2.5 g's ± 0.2 g. Then subject the PET to vibration of ten (10) g's for five (5) minutes at each of the frequencies 1020 Hz and 2080 Hz (see 3.14).

4.5.12.2 Transverse vibration. Rigidly mount the PET to the vibration table such that the radial axis of the PET is perpendicular to the direction of motion. Subject the PET to two (2) each thirty (30) minute sweeps over the frequency range of ten (10) hertz to 3500 hertz and back to ten (10) hertz while maintaining a constant 2.5 g ± 0.2 g. Then subject the PET to vibration of ten (10) g for five (5) minutes at each of the frequencies 1020 Hz, 2080 Hz and 3140 ± 100 Hz (see 3.14).

4.5.13 Mechanical shock. The PET shall be rigidly mounted during shock testing. After the shock tests outlined below, the PET shall be tested for resonant frequency (4.5.3.1), efficiency at resonance (4.5.3.2) and voltage step-up at resonance (4.5.3.3).

4.5.13.1 Longitudinal sawtooth. Rigidly mount the PET with its radial axis in a vertical plane and subject the PET to five (5) shock pulses of nine (9) millisecond duration sawtooth wave form whose peak force is 140 g's ± 14 g's, as measured by a calibrated "Peak G" meter or oscilloscope. Reverse the PET so that the shock is still parallel to the radial axis and repeat the test (see 3.13).

4.5.13.2 Transverse sawtooth. Rigidly mount the PET with its radial axis in a horizontal (transverse) plane. With the PET thus mounted, subject the PET to ten (10) shock pulses with the direction of the force applied perpendicular to the radial axis (see 3.13).

4.5.13.3 Longitudinal impulse. Mount the PET as in 4.5.13.1 and subject the transformer to five (5) pulses of nominal half sine wave shape having a peak amplitude of not less than 310 g's and duration 0.10 ± 0.05 millisecond. Impact oscillations as measured by the monitoring accelerometer shall be less than 30 g's twelve (12) milliseconds after initial pulse. Reverse the PET so that the pulse is still parallel to the radial axis but in the opposite direction, and subject it to five (5) pulses of nominal half sine wave shape having a peak amplitude of not less than 310 g's and duration of 0.10 ± 0.05 millisecond. Impact oscillations as measured by the monitoring accelerometer shall be less than 30 g's twelve (12) milliseconds after initial pulse (see 3.13).

4.5.13.4 Transverse impulse. Mount the PET as in 4.5.13.2 and subject the assembly to ten (10) pulses of nominal half sine wave shape whose peak amplitude is 910 ± 45 g's, and whose duration of 0.10 ± 0.05 millisecond. After-oscillations must not exceed 90 g at twelve milliseconds after initial pulse (see 3.13).

4.5.14 Thermal shock. PETs shall be tested in accordance with method 107D of MIL-STD-202. Test condition "B" shall apply, except that the number of cycles shall be 10 (see 3.9).

4.5.15 High temperature storage. PETs shall be subjected to a minimum storage period of 8 hours at plus 71°C. The ambient temperature shall then be gradually lowered to plus 52°C. Measurements shall then be made of the resonant frequency, efficiency at resonance and voltage step-up ratio in accordance with 4.5.4.1, 4.5.4.2 and 4.5.4.3 (see 3.10).

4.5.16 Low temperature storage. PETs shall be subjected to a minimum storage period of 2 hours at minus 65°C. The ambient temperature shall then be gradually raised to minus 54°C. Measurements shall then be made of the resonant frequency, efficiency at resonance and voltage step-up ratio in accordance with 4.5.5.1, 4.5.5.2 and 4.5.5.3 (see 3.11).

4.5.17 Humidity. PETs shall be exposed to a relative humidity of not less than 95 percent at a temperature of plus 52°C. Time of exposure shall be six hours. Upon completion of the exposure time, a voltage of 125 percent of the rated input voltage shall be applied to the primaries of the PET and it shall be driven at resonance for 48 hours during confirmatory inspection and for 8 hours during quality conformance inspection. After this time, all the PETs exposed to this test shall be tested for resonant frequency, efficiency at resonance and voltage step-up in accordance with 4.5.3.1, 4.5.3.2 and 4.5.3.3 (see 3.12).

Table I. Confirmatory Sample Inspection

Group I (all sample units)
Visual and mechanical examination (external)
Thermal shock
Resonant frequency
Efficiency at resonance
Voltage step-up at resonance
Input capacitance and dissipation factor
Secondary capacitance and dissipation factor
Terminal strength
Resistance to soldering heat
Induced voltage
Group II (three sample units)
Solderability
Reduced barometric pressure
High-temperature storage
Low-temperature storage
Humidity
Induced voltage
Visual and mechanical examination (external)
Visual and mechanical examination (internal)
Group III (nine sample units)
Life
Group IV (seven sample units)
Mechanical vibration
Mechanical shock
Induced voltage

Table II. Quality Conformance Group A Inspection

	AQL	
	Percent Defective Major	Minor
Thermal shock	0.65	-
Visual and mechanical examination (external)	0.65	-
Induced voltage	0.65	-
Resonant frequency	0.65	-
Efficiency at resonance	0.65	-
Voltage step-up at resonance	0.65	-
Input capacitance and dissipation factor	0.65	-
Secondary capacitance and dissipation factor	0.65	-

Table III. Quality Conformance Group B Inspection

Subgroup 1 (12 sample units)
High-temperature storage
Low-temperature storage
Subgroup 2 (20 sample units)
Humidity
Mechanical vibration
Mechanical shock
Induced voltage
Subgroup 3 (9 sample units minimum)
Life
Induced voltage
Visual and mechanical examination (external)
Subgroup 4 (5 sample units)
Solderability
Resistance to soldering heat
Terminal strength
Visual and mechanical inspection (internal)

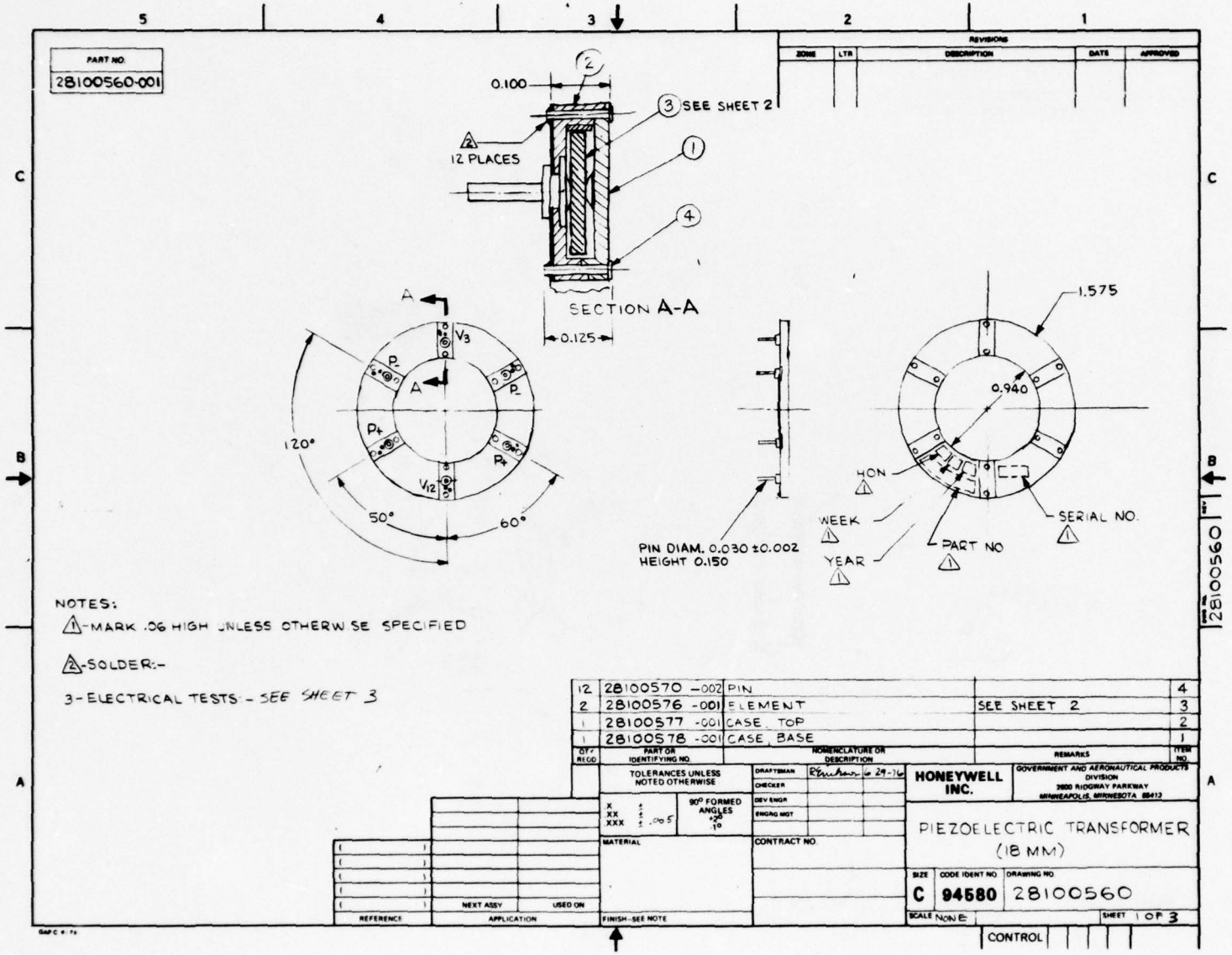

PART NO.
28100560-001
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
0.100
SEE SHEET 2
12 PLACES
SECTION A-A
0.125
1.575
0.940
120°
50°
60°
HON
WEEK
YEAR
PART NO
SERIAL NO.
PIN DIAM. 0.030 ±0.002
HEIGHT 0.150
NOTES:
1-MARK .06 HIGH UNLESS OTHERWISE SPECIFIED
2-SOLDER:-
3-ELECTRICAL TESTS:- SEE SHEET 3
12 28100570 -002 PIN 4
2 28100576 -001 ELEMENT SEE SHEET 2 3
1 28100577 -001 CASE, TOP 2
1 28100578 -001 CASE, BASE 1
QTY REQD
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
REMARKS
ITEM NO.
TOLERANCES UNLESS NOTED OTHERWISE
90° FORMED ANGLES
MATERIAL
FINISH-SEE NOTE
DRAFTSMAN
CHECKER
DEV ENGR
ENGNG MGT
CONTRACT NO
HONEYWELL INC.
GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION
2600 RIDGWAY PARKWAY
MINNEAPOLIS, MINNESOTA 55413
PIEZOELECTRIC TRANSFORMER
(18 MM)
SIZE
CODE IDENT NO.
DRAWING NO.
C
94580
28100560
SCALE NONE
SHEET 1 OF 3
CONTROL
REFERENCE
NEXT ASSY
USED ON
APPLICATION

Figure 1

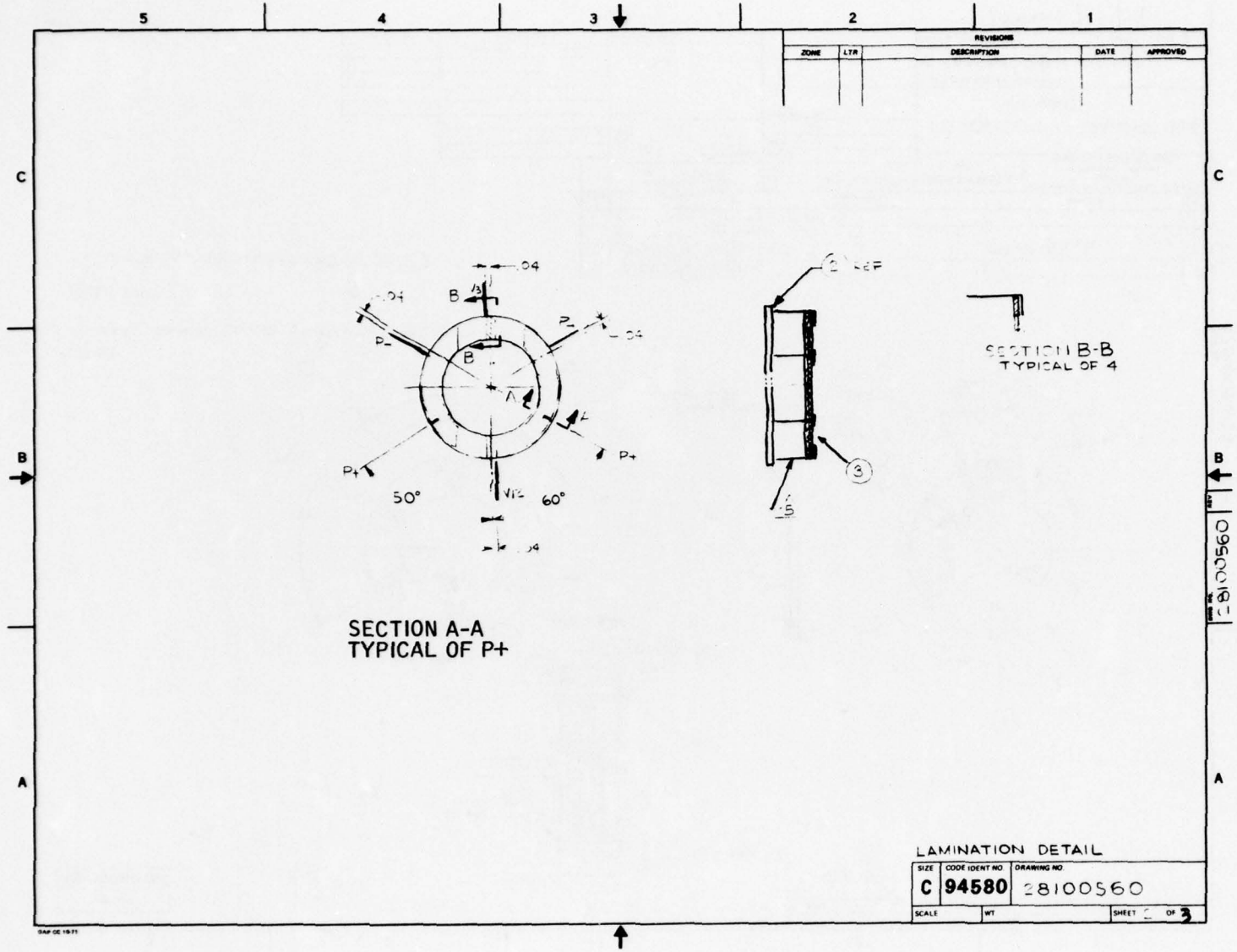


Figure 1 (Continued)

ELECTRICAL REQUIREMENTS

When a 5 volt (p-p) sine wave input voltage to the PET is applied in parallel to the primary terminals (P_+ and P_-) and the ceramic is driven at its primary resonant frequency with the electrical load on the V_{12} secondary terminal of 2 megohms and 8 pf, and V_3 terminal of 100 megohms and 3 pf, the packaged units shall meet the following electrical requirements.

Resonant Frequency:

22 ± 2°C	32.3 ± 1.6 kHz
52 ± 2°C	32.5 ± 1.6 kHz
-54 ± 2°C	31.6 ± 1.6 kHz

Stepup Voltage	V_{12} output/input voltage	V_3 output/input voltage
22 ± 2°C	110 ± 22	180 ± 35
52 ± 2°C	110 ± 22	180 ± 35
-54 ± 2°C	60 ± 12	100 ± 15

Percent Efficiency $\dfrac{\left(V_{12}^2 + V_3^2\right) \times 100}{(V_{in})\,(I_{in})\,(10 \times 10^6)}$

22 ± 2°C	38% min.
52 ± 2°C	38% min.
-54 ± 2°C	18% min.

Capacitance and Dissipation Factor: The input and output capacitance shall be measured at a nominal voltage and drive of 1 volt and 1 kHz.

Input Capacitance at Room Temperature		14 ± 1.4 nf
Secondary Capacitance at Room Temperature	V_{12} and V_3	10 pf max.
Input Percent Dissipation at Room Temperature		1.5% max.
Secondary Percent Dissipation at Room Temperature	V_{12} and V_3	1.5% max.

The package PET unit must meet the requirements as described in SCS-480 Rev. A for solderability, resistance to solder head, terminal strength, induced voltage, thermal shock, high and low temperature storage, humidity, mechanical shock and vibration, reduced barometric pressure, life and workmanship.

Figure 1 (Concluded)

Electrical Requirements

Size	Code Ident No.	Drawing No.
C	94580	28100560

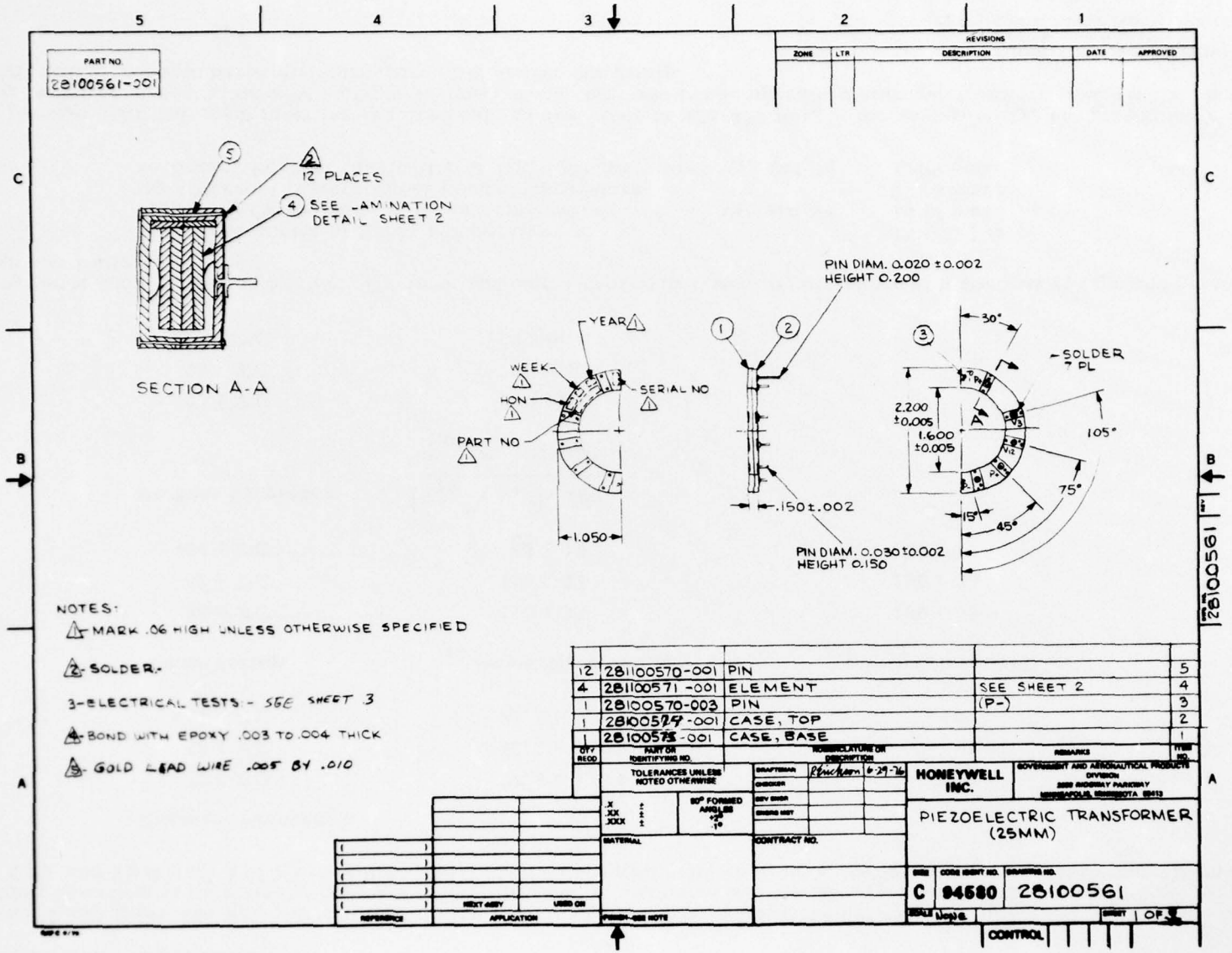

PART NO.
28100561-001
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
12 PLACES
SEE LAMINATION DETAIL SHEET 2
SECTION A-A
YEAR
WEEK
HON
PART NO
SERIAL NO
1.050
PIN DIAM. 0.020 ±0.002
HEIGHT 0.200
.150±.002
PIN DIAM. 0.030±0.002
HEIGHT 0.150
30°
SOLDER 7 PL
2.200 ±0.005
1.600 ±0.005
105°
75°
15°
45°
NOTES:
1. MARK .06 HIGH UNLESS OTHERWISE SPECIFIED
2. SOLDER.
3. ELECTRICAL TESTS - SEE SHEET 3
4. BOND WITH EPOXY .003 TO .004 THICK
5. GOLD LEAD WIRE .005 BY .010
12 28100570-001 PIN 5
4 28100571-001 ELEMENT SEE SHEET 2 4
1 28100570-003 PIN (P-) 3
1 28100579-001 CASE, TOP 2
1 28100578-001 CASE, BASE 1
QTY REQD
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
REMARKS
TYPE NO.
TOLERANCES UNLESS NOTED OTHERWISE
.X ±
.XX ±
.XXX ±
90° FORMED ANGLES +2° -1°
DRAFTSMAN Beecham 6-29-76
CHECKER
DEV ENGR
ENGRG MGT
MATERIAL
CONTRACT NO.
HONEYWELL INC.
GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION
2600 RIDGWAY PARKWAY
MINNEAPOLIS, MINNESOTA 55413
PIEZOELECTRIC TRANSFORMER (25MM)
SIZE C
CODE IDENT NO. 94580
DRAWING NO. 28100561
SCALE None
SHEET OF
CONTROL
REFERENCE
NEXT ASSY
USED ON
APPLICATION
FINISH-SEE NOTE
28100561 REV

Figure 2

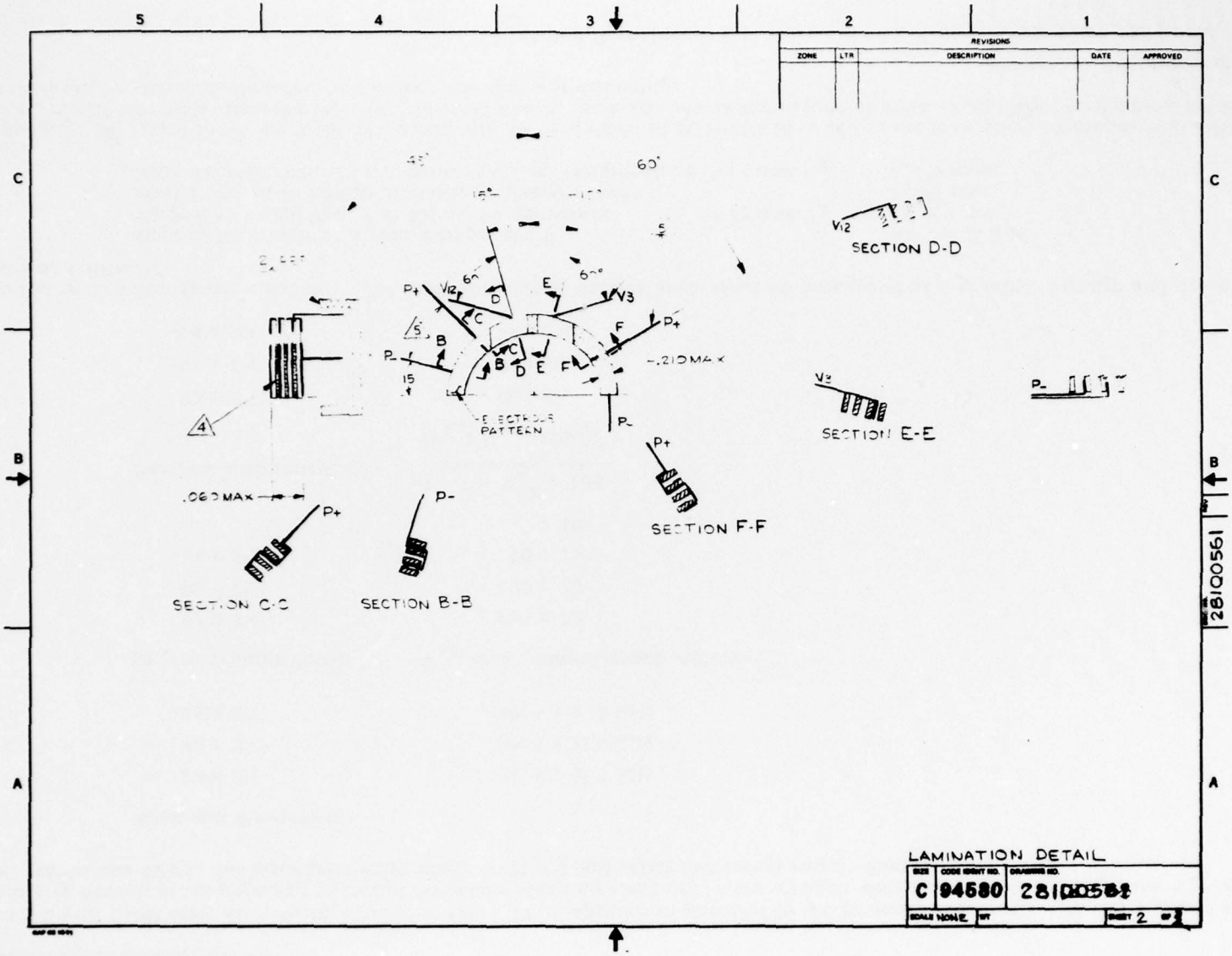


Figure 2 (Continued)

ELECTRICAL REQUIREMENTS

When a 5 volt (p-p) sine wave input voltage to the PET is applied in parallel to the primary terminals (P_+ and P_-) and the ceramic is driven at its primary resonant frequency with an electrical load on each secondary terminal (V_{12} and V_3) of 10 megohms and 10 pf, the packaged units shall meet the following electrical requirements.

Resonant Frequency:

22 ± 2°C	30.5 ± 1.5 kHz
52 ± 2°C	30.7 ± 1.5 kHz
-54 ± 2°C	29.5 ± 1.5 kHz

Stepup Voltage Ratio	V_{12} or V_3 output/input voltage
22 ± 2°C	195 ± 30
52 ± 2°C	195 ± 30
-54 ± 2°C	90 + 15 - 10

Percent Efficiency $= \dfrac{V_{12}^2 + V_3^2 \times 100}{(V_{in})(I_{in})(10 \times 10^6)}$

22 ± 2°C	50 min.
52 ± 2°C	50 min.
-54 ± 2°C	20 min.

Capacitance and Dissipation Factor: The input and output capacitance shall be measured at a nominal voltage and drive of 1 volt and 1 kHz.

Input Capacitance at Room Temperature		32.0 ± 3.2 nf
Secondary Capacitance at Room Temperature	V_{12} and V_3	15 pf max.
Input Percent Dissipation at Room Temperature		1.5% max.
Secondary Percent Dissipation at Room Temperature	V_{12} and V_3	1.5% max.

The package PET unit must meet the requirements as described in SCS-480 Rev. A for solderability, resistance to solder heat, terminal strength, induced voltage, thermal shock, high and low temperature storage, humidity, mechanical shock and vibration, reduced barometric pressure, life and workmanship.

Figure 2 (Concluded)

Electrical Requirements

Size	Code Ident No.	Drawing No.
C	94580	28100561

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